# A STUDY OF ICE CREAM STABILIZERS

DR. SAMUEL C. PRESCOTT, Sc.D.
ARTHUR HEIFETZ, S.B., AND
DAVID S. STANLEY, JR., S.M.

*Department of Biology and Public Health*
*Laboratory of Food Technology*

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## INTRODUCTION

The enormous increase in the use of ice cream as an article of food has brought it out of the class of luxuries obtainable only by the well-to-do, and made it a staple food of wide use. At the outset it is recognized that it is a food of high nutritive value, and its great consumption by all ages and classes of people is to be looked upon with favor.

With the production of ice cream on a large scale there arose numerous problems, chemical, sanitary, and practical in their aspects, with which manufacturers were confronted. One of these had to do with the use of so-called "stabilizers," that is, the introduction of small amounts of substances of colloidal nature which affected the size and character of ice crystal formation, and the consequent smoothness and uniformity of the product, and which furthermore played an important part in the maintenance of these qualities when the ice cream was kept in the hardening room or under other conditions met with in the trade.

The problem of finding the most efficient and practical ice cream stabilizer is therefore one that has been before the ice cream manufacturer since the beginning of the production of ice cream on a large scale. Gelatin was first employed and has been the most widely used stabilizer, but from time to time new products are put on the market that are claimed to outrival gelatin in securing the desired results.

It is obvious that the use of stabilizers is not to be regarded as a sophistication or adulteration, or an attempt to cheapen or lower the food value. It is, on the other hand, an improver of gustatory and commercial quality, and the quantity of such materials necessary to bring about the desired improvement is very small in relation to the whole volume of the ingredients of the ice cream. It is, however, of great importance that the stabilizer shall be free from objectionable types of bacteria, such as large numbers of *B. coli* or other types representative of insanitary materials or handling, from products of bacterial decomposition or spoilage, and from dirt, mold, or other material objectionable from the food standpoint.

Stabilizers fall in two distinct classes: those of animal origin, of which gelatin is the principal representative; and those of plant origin, including starch, dextrins and other products from seeds or cereals. Gelatin for use as a stabilizer must be of high grade, and should conform to all the requirements of a so-called "food-gelatin" insofar as purity, freedom from decomposition products and bacterial standards are concerned. Such gelatins may be made from bone tissue, "ossein," or from the thoroughly cleaned pieces of skins of the beef animals or of hogs. The products from these sources show variations in some of their physico-chemical qualities, but are essentially alike in their suitability for use as protective colloids. Representative large samples from a number of manufacturers were secured for the studies undertaken.

In recent years a number of products bearing trade names not descriptive of their source or composition have appeared on the market, and have obviously found users in the trade to warrant their merchandising. Among these substitutes for gelatin now on the market, the following, designated by their trade names, have been obtained for examination:

1. "Krabyn," a preparation made from the carob bean.
2. "Hygell," also a refined carob product.
3. "Tragon," of undetermined origin.
4. "Tragosol," probably nearly or quite identical with No. 3.
5. "Collace."
6. "Stabilor."
7. "Turnbow."
8. A material designated by us as "X" and reported to be similar to Collace.
9. Another product, Yelkin, was also subjected to examination, but was not utilized in the actual tests in ice cream manufacture in the plant.

There are numerous other products which are mentioned in the trade literature, such as Ace-Ee, Gelazone, etc.

## INVESTIGATION OF STABILIZING AGENTS

The purpose of this investigation has been to study this group of adjuncts, and to determine, if possible, which class of substances, the gelatins or the vegetable substitutes, were most satisfactory and therefore the best to use as ice cream stabilizers. Among the factors that were considered in such a comparison were the physico-

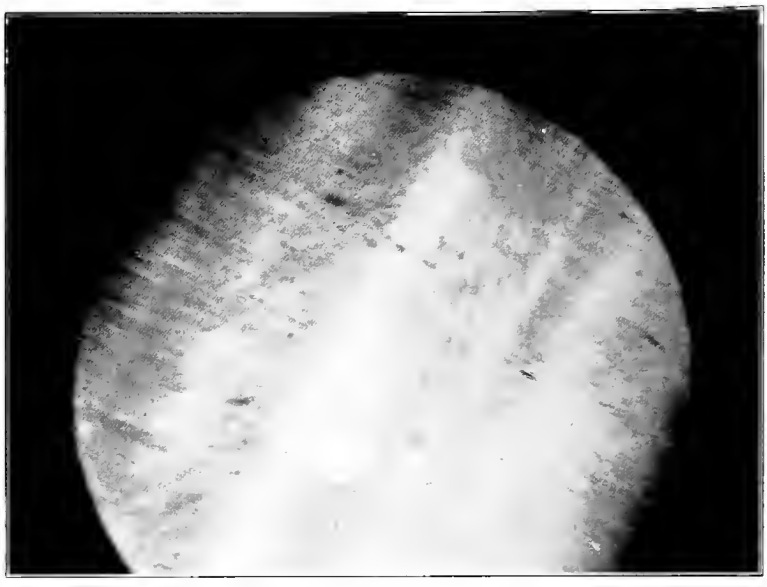
chemical characteristics of the stabilizers themselves, including appearance, odor, and color; solubility; reaction as determined by pH; viscosity. Biologically, each was examined with reference to its bacterial and mold content. These laboratory examinations having been carefully made, practical tests were then made in an ice cream plant where the product made with each type could be examined with reference to over-run obtained in the manufacture of ice cream, appearance and consistency of the ice cream when made and after standing in the hardening room, effect of melting down of the ice cream, flavor and the preference of the consumer with reference to flavor, smoothness and gustatory quality.

A study in all these respects was made on twelve stabilizers. Eight of these were supposedly 200 Bloom gelatins in powdered form that were obtained from eight different manufacturers. The other four were vegetable substitutes, namely, Krabyn, Tragon, Collace, and Stabilor. Partial tests were also made on several other samples of stabilizing agents.

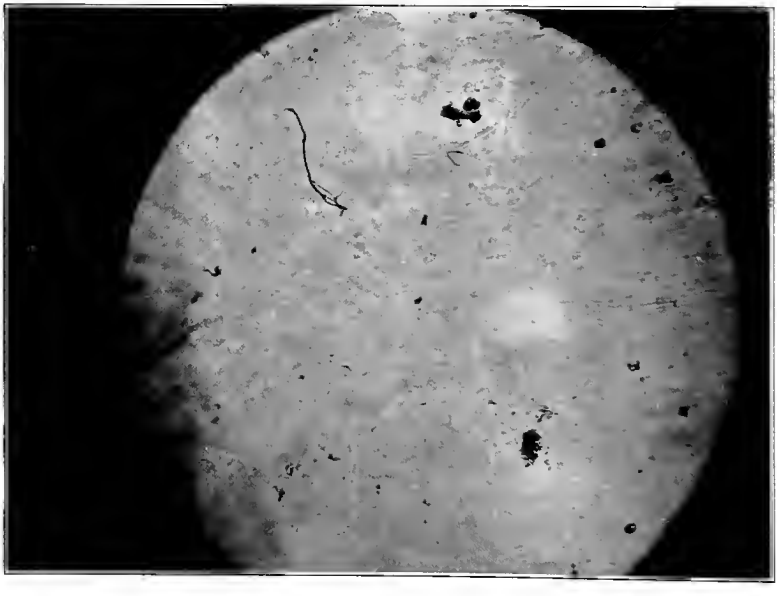
Appearance. To the naked eye the gelatins all appeared to be of even granulation, from light yellow to golden brown in color, and free from obvious dirt and foreign matter. This was specially noted by both the naked eye and microscopic examination.

Krabyn, Tragon, Collace, Stabilor, Turnbow and Substitute X are all finely divided powders, grayish to white in color and having few or many particles that are from brown to black in color, distributed through them. Yelkin is a dark brown mass, similar in appearance to cold molasses.

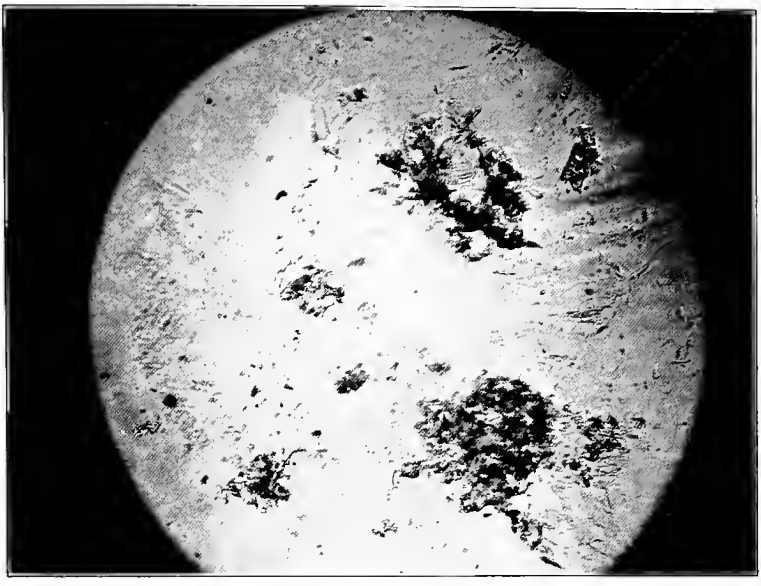
Solubility. The gelatins go into colloidal solution quite readily, especially if heated to about 37°C. The vegetable substitutes, however, present difficulty, and all form gummy masses or suspensions of finely divided material. An emulsion of 1% Yelkin was most difficult to prepare. It was necessary to resort to a mechanical shaker for forty-five minutes before a satisfactory emulsion could be obtained. Photomicrographs have been taken showing .3% solutions of gelatin and solutions of some of the vegetable substitutes in the concentrations in which they are used in ice cream manufacture. These photographs show discretely only the larger particles in the substrate. The gelatin solution is clear and shows no suspended particles, while the substitutes all show material of varied sizes in suspension. A few of these photographs are reproduced for illustrative purposes.



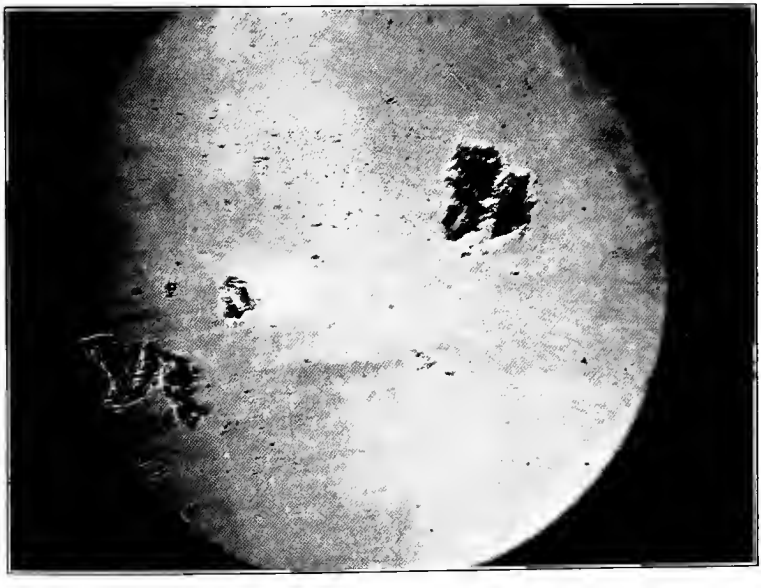
Photomicrograph of a .3% solution of Gelatin. Note the absence of particles in suspension.



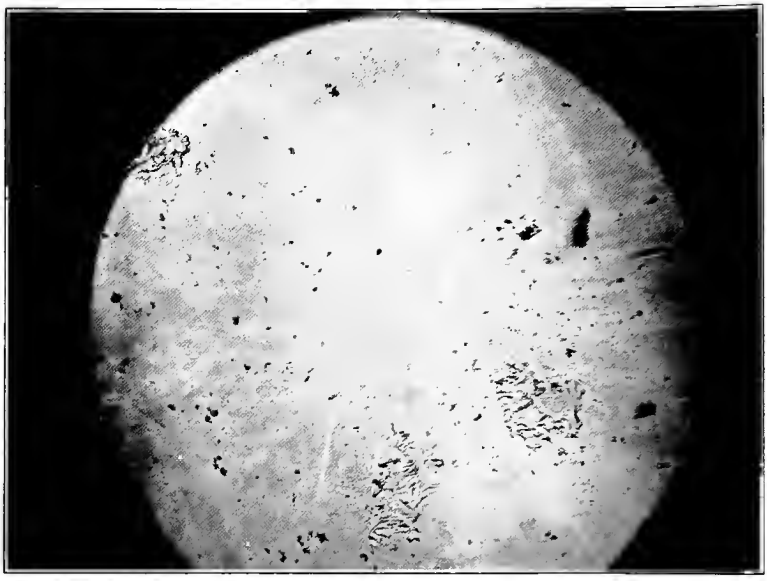
Photomicrograph of a .12% solution of Krabyn. The dark particles are often fragments of seed coats.



Photomicrograph of a .12% solution of Tragon.



Photomicrograph of a .3% solution of Collace.



Photomicrograph of a .15% solution of Stabilor.

COMPARATIVE PHYSICAL QUALITIES OF STABILIZER SUSPENSIONS

| *Sample* | *Color* | *Transparency* | *Odor* |
|---|---|---|---|
| Gelatin A | Yellow | Clear | Distinctly characteristic, unobjectionable |
| Gelatin B | White | Clear | Characteristic, unobjectionable |
| Gelatin C | White | Clear | Characteristic, unobjectionable |
| Gelatin D | White | Clear | Characteristic, unobjectionable |
| Gelatin E | Yellow | Clear | Characteristic, unobjectionable |
| Gelatin F | White | Clear | Characteristic, unobjectionable |
| Gelatin G | White | Clear | Characteristic, unobjectionable |
| Gelatin H | White | Faintly cloudy | Characteristic, unobjectionable |
| Collace | Grey-white | Opaque, pasty | Faintly vegetable, unobjectionable |
| Krabyn | Grey | Opaque, pasty | Faintly vegetable, slightly weedy |
| Tragon | Grey-white | Opaque, pasty | Faintly vegetable, unobjectionable |
| Yelkin | Brown | Opaque | Resembling vegetable oil |
| Stabilor | Grey-white | Opaque, pasty | Faintly vegetable, unobjectionable |
| Turnbow | Grey-white | Opaque, pasty | Faintly vegetable, unobjectionable |
| Substitute X | Grey-white | Opaque, pasty | Faintly vegetable, unobjectionable |
| Hygell | Grey-white | Opaque, pasty | Faintly vegetable, unobjectionable |

REACTION. pH. The pH of the stabilizers was determined by the Hellige Colorimetric Method.

| *Substance* | *pH* | *Substance* | *pH* |
|---|---|---|---|
| Gelatin A | 7.1 | Collace | 6.3 |
| Gelatin B | 4.7 | Krabyn | 6.0 |
| Gelatin C | 5.2 | Tragon | 6.5 |
| Gelatin D | 6.0 | Yelkin | 4.2 |
| Gelatin E | 6.3 | Stabilor | 5.4 |
| Gelatin F | 4.6 | Turnbow | 6.4 |
| Gelatin G | 5.6 | Substitute X | 6.4 |
| Gelatin H | 5.5 | Hygell | 5.6 |

VISCOSITY. Viscosity was determined on the McMichael Viscosimeter at 20°C., and using a No. 26 wire. All samples of gelatin are directly comparable when the same strength of solution is employed. With the products of vegetable origin it was impossible, however, to use the same concentration as with gelatin (5%). The best readings were obtained with 1% of the powder shaken up in warm water, allowed to stand for 15 minutes or so, cooled to 20°C. and then tested.

The following table shows that while the gelatins all fall within a reasonably narrow range, the vegetable products vary widely. The real significance of the viscosity figures is perhaps open to different interpretations, but it is obvious that because of the great dissimilarity in the character of the two classes of stabilizers examined, any direct comparison between them seems to be of little value. The gelatin solutions or suspensions retain their homogeneous character regardless of temperature, while the vegetable products become lumpy and swell irregularly when the suspension is prepared, and on cooling tend to appear as flocculent, gummy masses.

VISCOSITY TESTS

GELATIN

| *Substance* | *Concentration* | *Viscosity in Centipoises* |
|---|---|---|
| Gelatin A | 5% | .095 |
| Gelatin B | 5 | .115 |
| Gelatin C | 5 | .088 |
| Gelatin D | 5 | .110 |
| Gelatin E | 5 | .100 |
| Gelatin F | 5 | .110 |
| Gelatin G | 5 | .117 |
| Gelatin H | 5 | .110 |

| | | |
|---|---|---|
| | VEGETABLE PRODUCTS | |
| Collace | 1% | .370 |
| Krabyn | 1 | .681 |
| Tragon | 1 | * |
| Yelkin | 5 | .060 |
| Turnbow | 1 | .108 |
| Stabilor | 1 | .088 |
| Substitute X | 1 | .008 |
| Hygell | 1 | .130 |

* Too high for a reading.

The viscosity of the gelatin samples was also determined by means of a standard viscosity pipette, using a solution of 5% at a temperature of 60°C. A much wider range of results was here found, due in part, no doubt, to the differences in original stock and the methods of manufacture, difference in pH and other factors. In the case of the vegetable products this method could not be used with success as the gummy lumps clog the pipette and the readings cannot be taken with any degree of accuracy.

VISCOSITY AS DETERMINED ON A STANDARD VISCOSITY PIPETTE

| *Substance* | *Viscosity in millipoises* |
|---|---|
| Gelatin A | 52.5 |
| Gelatin B | 36.5 |
| Gelatin C | 32.3 |
| Gelatin D | 34.0 |
| Gelatin E | 46.5 |
| Gelatin F | 42.0 |
| Gelatin G | 48.0 |
| Gelatin H | 42.0 |

BACTERIOLOGICAL EXAMINATION. Notwithstanding the facts that small quantities of stabilizers are used and the ice cream is to be at once frozen and kept continually subjected to low temperature, it was believed desirable to submit all samples of these materials to careful and extensive bacteriological examination. It is recognized that materials of the types employed may vary greatly in bacterial content both as to numbers and types of organisms. It is important to know if objectionable or dangerous types of bacteria are present.

In order to have bacteriological data of real significance it is necessary to make more than a single casual examination for the total numbers of bacteria. Materials such as gelatins and vegetable preparations frequently vary greatly even in different portions of a single sample. It was therefore decided to subject each

of the substances under examination to at least twenty-five separate quantitative determinations, and to take the average of these, at each of the incubation temperatures used, as more fully representing the bacteriological condition.

Preliminary examinations showed that a dilution of 1–100 was satisfactory for most of the samples. In the case of one of the vegetable products, Krabyn, a dilution of 1–1000 was found to be necessary because of the irregularity of distribution and high mold count. Determinations were carried out on agar at incubation temperatures of 37°C., 20°C., and 0°C., for the enumeration of the bacteria which would grow at these temperatures. Liquefying bacteria were roughly determined by the use of gelatin at 20°C. and a mold assay by the use of maltose agar at 20°C. The presence of organisms of the colon aerogenes group was determined by use of duplicate cultures in lactose, dextrose and sucrose broth.

Because of the impossibility of making accurate mold counts or accurate counts of liquefying bacteria, the plan of recording the percentage of plates clearly showing these types of organisms was employed. In many instances plates showed no distinct mold colonies at the end of the first 24 hours, while at the end of 48 hours the plates would be so covered with myceleum or with spreading mold colonies that a direct clear-cut enumeration could not be made. One focus of infection might cover the whole plate. The results, so far as molds and liquefying bacteria are concerned, indicate therefore the percentage of samples of .01 gram each in which these organisms are present. Similarly, the figures given for fermenting types of organisms represent percentages of samples containing organisms of colon aerogenes types rather than actual numbers.

The summarized and averaged results of the twenty-five separate tests on each sample are taken as presenting a fair picture of the microbial quality of the product. The following tabulations present these results.

## BACTERIOLOGICAL EXAMINATION

### Gelatin A

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 28,200 | 131,000 | 124,500 |
| 20°C. | 4,850 | 100,000 | 119,000 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 0% | 34.60% | 38.50% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 53% | 58% | 58% |
| Lactose | 53 | 58 | 58 |
| Sucrose | 53 | 58 | 58 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 27.25% | 45.40% |
| 20° | 0 | 11.10 | 40.00 |

## BACTERIOLOGICAL EXAMINATION

### Gelatin B

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 2,500 | 2,700 | 3,200 |
| 20°C. | 200 | 2,800 | 6,000 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 0% | 13.50% | 28.00% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0% | 0% | 0% |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 7.7 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 27.25% | 45.40% |
| 20° | 0 | 11.10 | 40.00 |

## BACTERIOLOGICAL EXAMINATION

### Gelatin C

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 25 | 170 | 200 |
| 20°C. | 15 | 20 | 110 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 4.3% | 9.5% | 16.0% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0 | 0 | 0 |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 2.1% | 23.8% | 34.0% |
| 20° | 0 | 2.3 | 8.0 |

## BACTERIOLOGICAL EXAMINATION

### Gelatin D

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 3,600 | 8,400 | 8,600 |
| 20°C. | 200 | 250 | 4,300 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 0% | 12.50% | 15.00% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0 | 0 | 0 |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 54.50% | 82.00% | 85.00% |
| 20° | 0 | 40.00 | 62.50 |

## BACTERIOLOGICAL EXAMINATION

### Gelatin E

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 200 | 300 | 400 |
| 20°C. | 20 | 100 | 300 |
| 0°C. | 0 | 100 | 100 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 0% | 12.50% | 28.60% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0% | 0% | 0% |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 5 | 5 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 23.55% | 31.60% |
| 20° | 0 | 0 | 37.50 |

## BACTERIOLOGICAL EXAMINATION

### Gelatin F

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 1,100 | 3,800 | 3,800 |
| 20°C. | 200 | 2,700 | 3,900 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 35.20% | 100% | 100% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 4.5% | 11.7% | 12.0% |
| Lactose | 0 | 0 | 2.0 |
| Sucrose | 18.1 | 26.0 | 26.0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 41.1% | 44.0% |
| 20° | 0 | 2.9 | 38.0 |

## BACTERIOLOGICAL EXAMINATION

### Gelatin G

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 400 | 500 | 500 |
| 20°C. | 100 | 700 | 1,100 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 0% | 32.1% | 40.0% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0% | 0% | 0% |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 35.20% | 42.0% |
| 20° | 0 | 0 | 32.0 |

## BACTERIOLOGICAL EXAMINATION

### Gelatin H

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 15 | 50 | 70 |
| 20°C. | 0 | 0 | 25 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 0% | 2.6% | 10.0% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0% | 0% | 0% |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 15.7% | 16.0% |
| 20° | 0 | 0 | 6.0 |

## BACTERIOLOGICAL EXAMINATION

### Collace

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 570 | 700 | 950 |
| 20°C. | 90 | 3,200 | 4,400 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 37.50% | 50.00% | 59.40% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0% | 0% | 0% |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 87.50% | 91.00% |
| 20° | 0 | 72.70 | 87.50 |

## BACTERIOLOGICAL EXAMINATION

### Tragon

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 1,300 | 6,400 | 8,000 |
| 20°C. | 20 | 1,400 | 13,000 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 34.70% | 67.50% | 87.30% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 2.00% | 4.20% | 4.20% |
| Lactose | 0 | 0 | 2.08 |
| Sucrose | 2.08 | 2.08 | 4.16 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 83.4% | 97.50% | 100% |
| 20° | 0 | 79.60 | 95.80 |

## BACTERIOLOGICAL EXAMINATION

### KRABYN

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 16,000 | 17,000 | 18,000* |
| 20°C. | 2,000 | 14,000 | 15,000* |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 26.3% | 82.5% | 96.0% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 84.0% | 70.8% | 72.0% |
| Lactose | 6.00 | 33.3 | 56.0 |
| Sucrose | 62.0 | 60.0 | 66.0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 100% | 100% | 100% |
| 20° | 4.0 | 100 | 100 |

*The dilution used in obtaining the bacterial count per gram was 1–1,000

## BACTERIOLOGICAL EXAMINATION

### TURNBOW

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 18,500 | 41,000 | 67,000 |
| 20°C. | 8,500 | 43,500 | 154,000 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 35% | 85% | 85% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 90% | 90% | 90% |
| Lactose | 5 | 65 | 95 |
| Sucrose | 85 | 90 | 90 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 10% | 100% | 100% |
| 20° | 0 | 0 | 100 |

## BACTERIOLOGICAL EXAMINATION

### Hygell

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 1,600 | 3,000 | 4,000 |
| 20°C. | 13 | 750 | 1,500 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 1% | 13% | 36% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 6% | 14% | 18% |
| Lactose | 1 | 9 | 14 |
| Sucrose | 4 | 21 | 24 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 92% | 100% |
| 20° | 0 | 22 | 100 |

## BACTERIOLOGICAL EXAMINATION

### Substitute X

(Marked — Similar to Col-Ace)

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 84,300 | 98,400 | 98,400 |
| 20°C. | 8,400 | 130,000 | 163,600 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 100% | 100% | 100% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 5% | 5% | 5% |
| Lactose | 4 | 4 | 4 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 100% | 100% | 100% |
| 20° | 0 | 100 | 100 |

## BACTERIOLOGICAL EXAMINATION

YELKIN

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 1,600 | 3,000 | 3,300 |
| 20°C. | 70 | 230 | 1,200 |
| 0°C. | 40 | 90 | 270 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 2.3% | 40.4% | 58.0% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0% | 0% | 0% |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 30.9% | 64.0% |
| 20° | 0 | 2.3 | 34.0 |

## BACTERIOLOGICAL EXAMINATION

STABILOR

| | *Average of 25 determinations* | | |
|---|---|---|---|
| | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Number of bacteria per gram developing at different incubation temperatures | | | |
| 37°C. | 850 | 1,100 | 1,600 |
| 20°C. | 5 | 130 | 400 |
| 0°C. | 0 | 0 | 0 |
| *Liquefiers* | | | |
| Percentage of plates showing liquefaction of gelatin at 20°C. | 1% | 5% | 10% |
| *Fermentation Test* | | | |
| Percentage of fermentation tubes showing positive reaction for colon aerogenes at 37°C. | | | |
| Dextrose | 0% | 2% | 4% |
| Lactose | 0 | 0 | 0 |
| Sucrose | 0 | 0 | 0 |
| *Molds* | | | |
| Percentage of maltose agar plates showing positive growth | | | |
| 37° | 0% | 13% | 22% |
| 20° | 0 | 3 | 23 |

For the purpose of making direct comparison, the results of the microbiological examinations have been compiled into a series of tables which also serve as summaries of the data obtained.

SUMMARY OF BACTERIAL COUNTS PER GRAM ON THE DIFFERENT STABILIZERS AT 37°C.

| *Substance* | *24 hrs.* | *48 hrs.* | *72 hrs.* |
|---|---|---|---|
| Gelatin A | 28,200 | 121,000 | 124,500 |
| Gelatin B | 2,500 | 2,800 | 3,200 |
| Gelatin C | 25 | 170 | 200 |
| Gelatin D | 3,600 | 8,400 | 8,600 |
| Gelatin E | 200 | 300 | 400 |
| Gelatin F | 1,100 | 3,800 | 3,800 |
| Gelatin G | 400 | 500 | 500 |
| Gelatin H | 15 | 50 | 70 |
| Collace | 570 | 700 | 900 |
| Tragon | 1,300 | 6,400 | 8,000 |
| Yelkin | 1,600 | 3,000 | 3,300 |
| Krabyn (1–1000 dilution) | 16,000 | 17,000 | 18,000 |
| Stabilor | 850 | 1,100 | 1,600 |
| Turnbow | 18,500 | 41,000 | 67,000 |
| Hygell | 1,600 | 3,000 | 4,000 |
| Substitute X | 84,300 | 98,400 | 98,400 |

SUMMARY OF BACTERIAL COUNTS PER GRAM ON THE DIFFERENT STABILIZERS AT 20°C.

| *Substance* | *24 hrs.* | *48 hrs.* | *72 hrs.* |
|---|---|---|---|
| Gelatin A | 4,850 | 100,000 | 119,500 |
| Gelatin B | 200 | 2,800 | 6,000 |
| Gelatin C | 15 | 20 | 110 |
| Gelatin D | 200 | 250 | 4,300 |
| Gelatin E | 20 | 100 | 300 |
| Gelatin F | 200 | 2,700 | 3,900 |
| Gelatin G | 100 | 700 | 1,100 |
| Gelatin H | 0 | 0 | 25 |
| Collace | 90 | 3,200 | 4,400 |
| Tragon | 20 | 1,400 | 13,000 |
| Yelkin | 70 | 280 | 1,200 |
| Krabyn (1–1000 dilution) | 2,000 | 14,000 | 15,000 |
| Stabilor | 5 | 130 | 400 |
| Turnbow | 8,500 | 43,500 | 154,000 |
| Hygell | 13 | 750 | 1,500 |
| Substitute X | 8,400 | 130,500 | 163,600 |

## SUMMARY OF BACTERIAL COUNTS PER GRAM ON THE DIFFERENT STABILIZERS AT 0°C.

| *Substance* | *24 hrs.* | *48 hrs.* | *72 hrs.* |
|---|---|---|---|
| Gelatin A | 0 | 0 | 0 |
| Gelatin B | 0 | 0 | 0 |
| Gelatin C | 0 | 0 | 0 |
| Gelatin D | 0 | 0 | 0 |
| Gelatin E | 0 | 100 | 100 |
| Gelatin F | 0 | 0 | 0 |
| Gelatin G | 0 | 0 | 0 |
| Gelatin H | 0 | 0 | 0 |
| Collace | 0 | 0 | 0 |
| Tragon | 0 | 0 | 0 |
| Yelkin | 40 | 90 | 270 |
| Krabyn | 0 | 0 | 0 |
| Stabilor | 0 | 0 | 0 |
| Turnbow | 0 | 0 | 0 |
| Hygell | 0 | 0 | 0 |
| Substitute X | 0 | 0 | 0 |

## SUMMARY OF PERCENTAGE OF PLATES SHOWING LIQUEFACTION OF GELATIN AT 20°C.

| *Substance* | *24 hrs.* | *48 hrs.* | *72 hrs.* |
|---|---|---|---|
| Gelatin A | 0.00% | 34.60% | 38.50% |
| Gelatin B | 0.00 | 13.50 | 28.00 |
| Gelatin C | 4.30 | 9.50 | 16.00 |
| Gelatin D | 0.00 | 12.50 | 15.00 |
| Gelatin E | 0.00 | 12.50 | 28.60 |
| Gelatin F | 55.20 | 100.00 | 100.00 |
| Gelatin G | 0.00 | 32.10 | 40.00 |
| Gelatin H | 0.00 | 2.60 | 10.00 |
| Collace | 35.75 | 50.00 | 59.40 |
| Tragon | 34.70 | 67.50 | 87.30 |
| Yelkin | 2.30 | 40.40 | 58.00 |
| Krabyn | 26.30 | 82.50 | 96.00 |
| Stabilor | 1.00 | 5.00 | 10.00 |
| Turnbow | 35.00 | 85.00 | 85.00 |
| Hygell | 1.00 | 13.00 | 36.00 |
| Substitute X | 100.00 | 100.00 | 100.00 |

SUMMARY OF PERCENTAGE OF FERMENTATION TUBES SHOWING GAS FORMATION. POSITIVE PRESUMPTIVE REACTIONS FOR COLON AEROGENES GROUP IN DEXTROSE, LACTOSE AND SUCROSE BROTHS AT 37°C.

| | Dextrose | | | Lactose | | | Sucrose | | |
|---|---|---|---|---|---|---|---|---|---|
| *Substance* | *24 hrs.* | *48 hrs.* | *72 hrs.* | *24 hrs.* | *48 hrs.* | *72 hrs.* | *24 hrs.* | *48 hrs.* | *72 hrs.* |
| Gelatin A | 53.00% | 58.00% | 58.00% | 53.00% | 58.00% | 58.00% | 53.00% | 58.00% | 58.00% |
| Gelatin B | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.70 |
| Gelatin C | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gelatin D | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gelatin E | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.00 | 5.00 |
| Gelatin F | 4.50 | 11.70 | 12.00 | 0.00 | 0.00 | 2.00 | 18.10 | 26.00 | 26.00 |
| Gelatin G | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gelatin H | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Collace | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tragon | 2.00 | 4.20 | 4.20 | 0.00 | 0.00 | 2.08 | 2.08 | 2.08 | 4.16 |
| Yelkin | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Krabyn | 64.00 | 70.80 | 72.00 | 6.00 | 33.30 | 56.00 | 62.00 | 62.00 | 66.00 |
| Stabilor | 0.00 | 2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Turnbow | 90.00 | 90.00 | 90.00 | 5.00 | 65.00 | 95.00 | 85.00 | 90.00 | 90.00 |
| Hygell | 6.00 | 14.00 | 18.00 | 1.00 | 9.00 | 14.00 | 4.00 | 21.00 | 24.00 |
| Substitute X | 5.00 | 5.00 | 5.00 | 4.00 | 4.00 | 4.00 | 0.00 | 0.00 | 0.00 |

SUMMARY OF PERCENTAGE OF MALTOSE AGAR PLATES SHOWING POSITIVE MOLD GROWTH AT 37°C.

| *Substance* | *24 hrs.* | *48 hrs.* | *72 hrs.* |
|---|---|---|---|
| Gelatin A | 5.56% | 33.00% | 50.00% |
| Gelatin B | 0.00 | 27.25 | 45.40 |
| Gelatin C | 2.10 | 23.80 | 34.00 |
| Gelatin D | 54.50 | 82.00 | 85.00 |
| Gelatin E | 0.00 | 23.55 | 31.60 |
| Gelatin F | 0.00 | 41.10 | 44.00 |
| Gelatin G | 0.00 | 35.20 | 42.00 |
| Gelatin H | 0.00 | 15.70 | 16.00 |
| Collace | 0.00 | 87.50 | 91.00 |
| Tragon | 83.40 | 97.50 | 100.00 |
| Yelkin | 0.00 | 30.00 | 64.00 |
| Krabyn | 100.00 | 100.00 | 100.00 |
| Stabilor | 0.00 | 13.00 | 22.00 |
| Turnbow | 10.00 | 100.00 | 100.00 |
| Hygell | 0.00 | 92.00 | 100.00 |
| Substitute X | 100.00 | 100.00 | 100.00 |

SUMMARY OF PERCENTAGE OF MALTOSE AGAR PLATES SHOWING POSITIVE MOLD GROWTH AT 20°C.

| *Substance* | *24 hrs.* | *48 hrs.* | *72 hrs.* |
|---|---|---|---|
| Gelatin A | 0.00% | 14.30% | 42.90% |
| Gelatin B | 0.00 | 11.00 | 40.00 |
| Gelatin C | 0.00 | 2.30 | 8.00 |
| Gelatin D | 0.00 | 40.00 | 62.50 |
| Gelatin E | 0.00 | 0.00 | 37.50 |
| Gelatin F | 0.00 | 2.90 | 38.00 |
| Gelatin G | 0.00 | 0.00 | 32.00 |
| Gelatin H | 0.00 | 0.00 | 6.00 |
| Collace | 0.00 | 72.70 | 87.50 |
| Tragon | 0.00 | 79.60 | 95.80 |
| Yelkin | 0.00 | 2.30 | 34.00 |
| Krabyn | 4.00 | 100.00 | 100.00 |
| Stabilor | 0.00 | 3.00 | 23.00 |
| Turnbow | 0.00 | 0.00 | 100.00 |
| Hygell | 0.00 | 22.00 | 100.00 |
| Substitute X | 0.00 | 100.00 | 100.00 |

The microbic content of stabilizing agents may be of importance from two standpoints.

1. If the number of organisms of liquefying and of fermenting types is very high, objection to their use may be made on grounds of sanitary quality.

2. If molds are present in large numbers the objection may be raised that the product is of inferior quality, even though it is not in any respect a menace to health.

In other words, there are two aspects to be considered in the microbiological examination of food adjuncts, one of which is concerned with the sanitary side, the other with the problem of commercial grade or quality. One deals with the possibility of effect on the health of the consumer, the other is largely a matter of esthetics.

It is evident from the study of the tables that the gelatins varied considerably in bacterial content, but with the exception of one sample which gave high results, the gelatins as a whole gave figures of a low order of magnitude, averaging 2,396 per gram. Even including the one unusually high sample, the average is 17,648, which is entirely within the permissible limits for food gelatins.

The average count found for the vegetable substitutes is 8,137, which is also within limits free from objection so far as mere numbers are concerned.

The vegetable products, however, show a distinctly higher percentage of fermenting types, nearly three times as many in each of the substrates employed for test. They also showed a much higher average concentration of liquefying types.

The gelatin samples as a class also show a very much lower mold content than was found in the vegetable stabilizers. On the basis of the method of examination practically twice as many plates showed growth of molds in the latter as in the former. It will be noted that five out of the eight samples of the vegetable products showed molds in every hundredth of a gram of the product when the plates were incubated at either 20° or 37° for 72 hours, and one other gave nearly as high results. Furthermore, the character of the molds themselves varied greatly in the two classes of materials. The gelatins showed in general very small slow-growing types of colonies, while the vegetable products gave rapidly growing types which in 48 hours covered the whole plate.

The general consideration of all the microbiological data there-

fore leads one to the opinion that the gelatins are distinctly to be preferred as agents for the stabilization of ice cream.

Plant Tests. In addition to the laboratory studies on the characteristics of stabilizers, it was deemed advisable, in order to enhance the value of this study, to carry out some tests of actual performance when ice cream, containing these adjuncts, are produced commercially on a plant scale. We were fortunate in securing the coöperation of a large producer who was willing not only to permit such a test, but to give much practical advice and assistance in carrying out the work. Accordingly, twelve of the stabilizers previously described, and especially those which are most employed as stabilizers, have been studied practically by such a plant test.

Manufacture of Ice Cream. The cream was manufactured in the plant of one of the large ice cream manufacturers of Greater Boston. In all, twelve batches of 300 gallons each were manufactured. Each batch contained the same ingredients except for the stabilizer, and all were made as nearly as possible under the same conditions as the others.

The mix was prepared in the morning, pasteurized at a temperature of 155°F. for thirty minutes, homogenized at a pressure of 2,500 pounds and then stored in the vats until the following morning when it was frozen.

FORMULA

| | |
|---|---|
| Total solids | 38.46% |
| Fat | 12.00 |
| Solids not fat | 10.00 |
| Gelatin | .30 |
| Sugar | 16.00 |
| Egg yolk | .13 |
| Salt | .03 |

In the ice creams made with substitutes, the amounts of substitutes used were as follows:

| | |
|---|---|
| Krabyn | .12% |
| Tragon | .12 |
| Collace | .30 |
| Stabilor | .15 |

Viscosity of Mixes. The viscosities of the mixes were taken after pasteurization and homogenization, and then again just before freezing, which was an interval of approximately 24

hours. A viscosity pipette was used, the mix and pipette both being at a temperature of 40°F. Readings were also taken between the 0 and 24 hour interval but they are not comparable due to the fact that they were not taken at regular intervals. The readings are expressed in terms of seconds.

| *Substance* | *Initiol Viscosity* | *Final Viscosity* | *Increase* | *Decrease* |
|---|---|---|---|---|
| Gelatin A | 160 | 173 | 13 | ... |
| Gelatin B | 152 | 155 | 3 | ... |
| Gelatin C | 150 | 165 | 15 | ... |
| Gelatin D | 137 | 181 | 44 | ... |
| Gelatin E | 123 | 152 | 29 | ... |
| Gelatin F | 124 | 175 | 51 | ... |
| Gelatin G | 129 | 190 | 61 | ... |
| Gelatin H | 110 | 139 | 29 | ... |
| Krabyn | 147 | 149 | 2 | ... |
| Tragon | 305 | 188 | .. | 117 |
| Collace | 257 | 243 | . | 14 |
| Stabilor | 433 | 314 | .. | 119 |

Acidity of Mixes. The initial acidity was taken after the mix had been pasteurized and homogenized, and the final acidity just before freezing. Acidity was determined by titration against N/10 sodium hydroxide.

| *Substance* | *Initial Acidity* | *Final Acidity* | *Increase* | *Decrease* |
|---|---|---|---|---|
| Gelatin A | .21% | .19% | ... | .02% |
| Gelatin B | .24 | .22 | ... | .02 |
| Gelatin C | .20 | .19 | ... | .01 |
| Gelatin D | .23 | .23 | ... | ... |
| Gelatin E | .20 | .20 | ... | ... |
| Gelatin F | .22 | .23 | .01% | ... |
| Gelatin G | .22 | .23 | .01 | . |
| Gelatin H | .23 | .23 | ... | ... |
| Krabyn | .23 | .24 | .01 | ... |
| Tragon | .21 | .20 | ... | .01 |
| Collace | .21 | .19 | ... | .02 |
| Stabilor | .21 | .20 | ... | .01 |

These results indicate that no marked change in acidity of the mix is introduced by any of the stabilizing agents considered in this study.

DATA OF FREEZING TIME, WHIPPING TIME, OVER-RUN, AND TEMPERATURE ON THE TWELVE ICE CREAMS

| *Sample* | *Temperature* | *Freezing time in seconds* | *Whipping time in seconds* | *Total of freezing and whipping time in seconds* | *Over-run* | *Temperature at which ice cream was dropped* |
|---|---|---|---|---|---|---|
| A | −11.5°F. | 142 | 145.5 | 287.5 | 100% | 24°F. |
| B | −7.0° | 174 | 142 | 316 | 100 | 24° |
| C | −8.7° | 168 | 173 | 343 | 105 | 24° |
| D | −10.0° | 158 | 120 | 278 | 100 | 24° |
| E | −7.7° | 210 | 154 | 364 | 105 | 24° |
| F | −10.3° | 158 | 142 | 300 | 102 | 24° |
| G | −6.0° | 160 | 175 | 335 | 100 | 23° |
| H | −6.0° | 198 | 138 | 336 | 100 | 24° |
| Krabyn | −6.0° | 191 | 114 | 305 | 102 | 24° |
| Tragon | −8.0° | 150 | 154 | 304 | 105 | 26° |
| Collace | .... | .... | .... | .... | .... | .... |
| Stabilor | −7.5° | 165 | 139 | 304 | 100 | 25° |

DATA ON FREEZING TIME, WHIPPING TIME, AND TEMPERATURE, ON THE TWELVE ICE CREAMS IN DETERMINING MAXIMUM OVER-RUN

| *Sample* | *Temperature* | *Freezing time in seconds* | *Whipping time in seconds* | *Total of freezing and whipping time in seconds* | *Maximum over-run* | *Draw-rite reading* |
|---|---|---|---|---|---|---|
| A | −10.5°F. | 219 | 518 | 737 | 140% | 3.5 |
| B | −7.0° | 167 | 373 | 540 | 140 | 3.5 |
| C | −10.0° | 175 | 695 | 870 | 137 | 3.5 |
| D | −10.0° | 164 | 383 | 547 | 137 | 3.5 |
| E | −6.0° | 206 | 357 | 563 | 140 | 3.5 |
| F | −10.0° | 162 | 379 | 541 | 140 | 3.5 |
| G | −6.0° | 197 | 527 | 724 | 130 | 3.5 |
| H | −6.0° | 211 | 548 | 756 | 136 | 3.5 |
| Krabyn | −5.0° | 198 | 534 | 732 | 140 | 3.5 |
| Tragon | −8.0° | 147 | 295 | 442 | 140 | 3.5 |
| Collace | −7.0° | 162 | 443 | 605 | 120 | 3.5 |
| Stabilor | −6.0° | 183 | 344 | 527 | 120 | 3.5 |

The data on Freezing Time, Whipping Time and Over-run, while not allowing a very accurate basis of comparison due to the wide differences in temperature, show that the gelatin-containing ice creams are capable of being whipped to produce a maximum over-run which averages 137.5%, while the average maximum over-run for the substitute is but 130%.

This leads to the assumption that if the gelatin and substitute mixes were subjected to the same freezing temperature, the desired over-run could be obtained more easily and more quickly with a gelatin mix than with a substitute mix.

Draw-rite Reading. The draw-rite reading, which shows us when the cream has been frozen sufficiently, is really an ammeter reading which measures the increased number of amperes required by the stirrer motor to do the work required as the material freezes.

In practice the cream is frozen until the draw-rite reading indicates, by the increased amperage necessary to pull the motor, that the ice cream is of sufficient consistency to be whipped. When the indicator reaches the required point, it is necessary to turn off the brine and start the whipping process.

## STORAGE

The twelve samples of ice cream were placed in 2½-gallon cans and were placed in the hardening room as they were made. This resulted in some of the samples being in the hardening room for a longer period of time than others, but at the low temperature at which the hardening room is kept, there is apt to be very little change in the cream, if any.

The hardening room is kept at a temperature of 0°F. to −25°F., and at this temperature the cream once frozen undergoes but little change. When the entire batch of creams had been prepared and the last batch had been in the hardening room for 48 hours, they were removed and placed in Frigidaire Ice Cream cabinets for a period of two weeks. It was after the ice creams were in the cabinets for two weeks that the tasting tests were run.

The following data which show the percentage of water frozen in both the gelatin and substitute creams were obtained by taking the temperature at the center and outside edge of the cans as they were undergoing the process of hardening, and then converting these figures by means of a table. It is said that the greater the percentage of water frozen during the first few hours in the hardening room, the smaller are the ice crystals formed.

The best comparison can be made between Gelatin "E" and Krabyn, which were placed in the hardening room at approximately the same time and hence were kept under the same conditions.

Tragon and Stabilor were also placed in the hardening room together and can also be accurately compared.

The curves of these determinations are shown in Graphs I and II.

## PERCENTAGE OF WATER FROZEN IN MIXES DURING 24-HOUR HARDENING PERIOD

### Gelatin C

| *Time* | *Room Temp. °F.* | *Cream Temp. °F. Edge* | *Center* | *Ave. Drop* | *% Water Frozen Edge* | *Center* | *Ave. Gain* | *Total % Frozen* |
|---|---|---|---|---|---|---|---|---|
| 9 a.m. | −16 | 18 | 22 | | 66 | 52 | | 59.0 |
| 10 a.m. | | 15 | 22 | 1.5 | 72 | 52 | 3.0 | 62.0 |
| 12 m. | | 10 | 22 | 2.5 | 77 | 52 | 2.5 | 64.5 |
| 1 p.m. | | 7 | 22 | 1.5 | 81 | 52 | 2.0 | 66.5 |
| 2 p.m. | | 7 | 21 | 0.5 | 81 | 57 | 2.5 | 69.0 |
| 3 p.m. | | 7 | 19 | 1.0 | 81 | 64 | 3.5 | 72.5 |
| 4 p.m. | −20 | 3 | 13 | 5.0 | 84 | 73 | 6.0 | 78.5 |
| 5 p.m. | −18 | 3 | 13 | 0.0 | 84 | 73 | 0.0 | 78.5 |
| 9 a.m. | −12 | −4 | −2 | 11.0 | 88 | 87 | 9.0 | 87.5 |
| Ave. | −15.6 | | | | | | | |

### Gelatin E

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 a.m. | −21 | 15 | 17 | | 72 | 65 | | 68.5 |
| 12 m. | −20 | 3 | 16 | 6.5 | 84 | 69 | 8.0 | 76.5 |
| 2 p.m. | −14 | −1 | 6 | 7.0 | 87 | 82 | 8.0 | 84.5 |
| 4 p.m. | −8 | −2 | 5 | 1.0 | 87 | 83 | 0.5 | 85.0 |
| 9 a.m. | −20 | −16 | −14 | 16.5 | 90+ | 90+ | 5.0 | 90.0+ |
| Ave. | −16.6 | | | | | | | |

### Gelatin H

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 a.m. | −17 | 18 | 23 | | 66 | 47 | | 56.5 |
| 12 m. | −17 | 13 | 23 | 2.5 | 73 | 47 | 3.5 | 60.0 |
| 2 p.m. | −17 | 10 | 22 | 2.0 | 77 | 52 | 4.5 | 64.5 |
| 4 p.m. | −13 | 9 | 17 | 3.0 | 78 | 67 | 8.0 | 72.5 |
| 5 p.m. | −10 | 8 | 15 | 1.5 | 79 | 72 | 3.0 | 75.5 |
| 9 a.m. | −16 | −6 | −6 | 17.5 | 89 | 89 | 13.5 | 89.0 |

### Krabyn

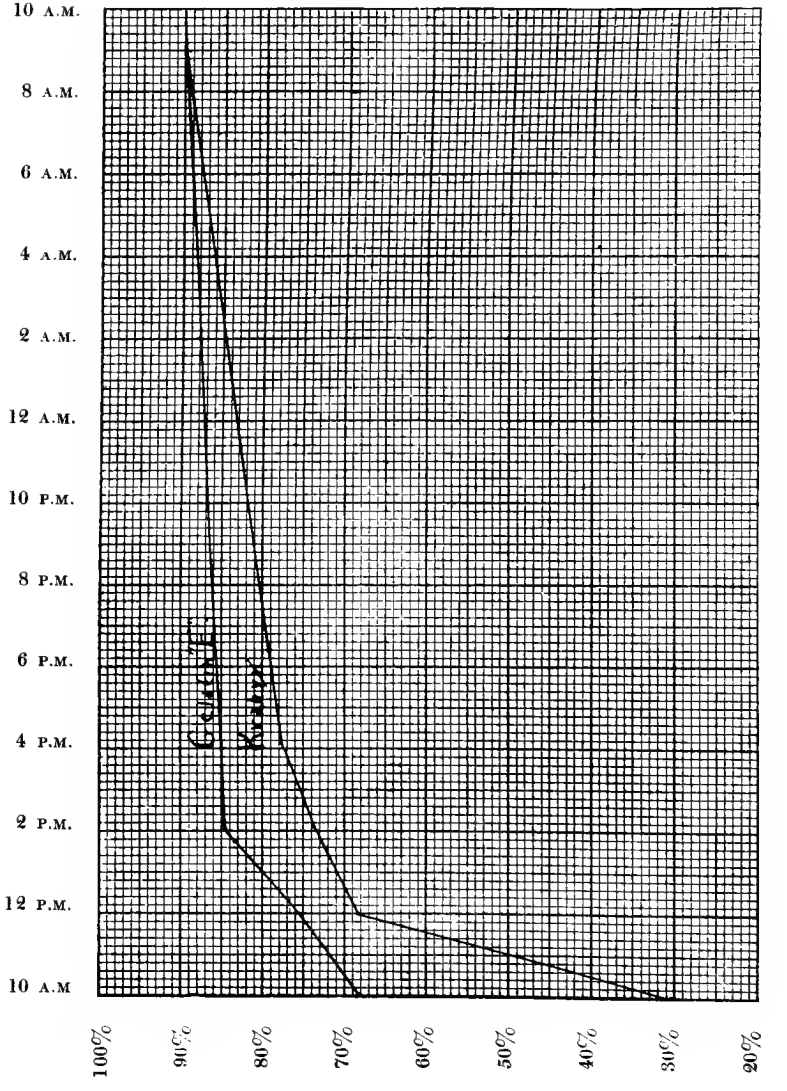
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 a.m. | −21 | 20 | 28 | | 61 | 0 | | 30.5 |
| 12 m. | −20 | 16 | 21 | 5.5 | 69 | 57 | 32.5 | 63.0 |
| 2 p.m. | −14 | 7 | 18 | 6.0 | 81 | 66 | 10.5 | 73.5 |
| 4 p.m. | −8 | 6 | 16 | 4.5 | 86 | 69 | 4.0 | 77.5 |
| 9 a.m. | −20 | −14 | −12 | 21.0 | 90+ | 90+ | 12.5 | 90.0+ |

### Tragon

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 a.m. | −14 | 16 | 24 | | 69 | 43 | | 56.0 |
| 12 m. | −12 | 10 | 14 | 8.0 | 77 | 72 | 18.5 | 74.5 |
| 2 p.m. | −10 | 9 | 14 | 0.5 | 78 | 72 | 0.5 | 75.0 |
| 4 p.m. | −12 | 9 | 13 | 0.5 | 78 | 73 | 0.5 | 75.5 |
| 5 p.m. | −11 | 8 | 11 | 1.5 | 79 | 76 | 2.0 | 77.5 |
| 9 a.m. | −16 | −10 | −7 | 18.0 | 90 | 89 | 12.0 | 69.5 |

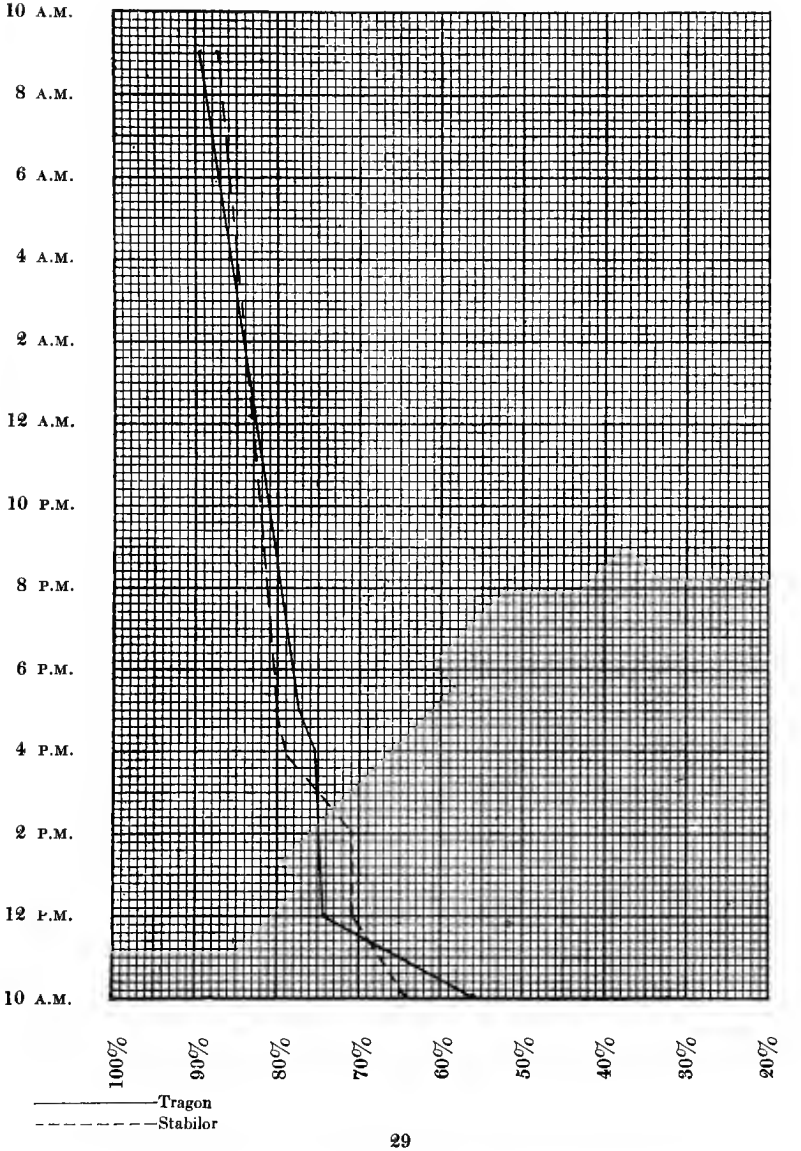
## GRAPH I

GRAPH SHOWING THE PERCENTAGE OF WATER FROZEN IN ICE CREAM MIXES DURING THE 24-HOUR HARDENING PERIOD



# GRAPH II

## GRAPH SHOWING THE PERCENTAGE OF WATER FROZEN IN ICE CREAM MIXES DURING THE 24-HOUR HARDENING PERIOD

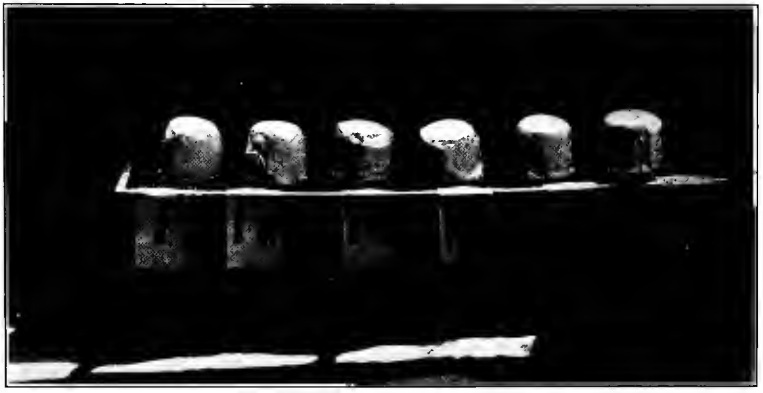


| *Time* | *Room Temp. °F* | *Cream Edge* | *Temp. °F. Center* | *Ave. Drop* | *% Water Frozen Edge* | *Center* | *Ave. Gain* | *Total % Frozen* |
|---|---|---|---|---|---|---|---|---|
| | | | COLLACE | | | | | |
| 10 a.m. | −6 | 20 | 24 | | 62 | 42 | | 52.5 |
| 12 m. | −4 | 14 | 18 | 6.9 | 72 | 65 | 16.0 | 68.5 |
| 2 p.m. | −2 | 12 | 15 | 2.5 | 75 | 75 | 4.5 | 73.0 |
| 4 p.m. | +1 | 11 | 14 | 1.0 | 76 | 72 | 1.0 | 74.0 |
| 5 p.m. | 0 | 10 | 13 | 1.0 | 72 | 73 | 1.0 | 75.0 |
| 9 a.m. | −9 | −2 | −1 | 13.0 | 87 | 87 | 12.0 | 87.0 |
| | | | STABILOR | | | | | |
| 10 a.m. | −14 | 14 | 21 | | 72 | 57 | | 64.5 |
| 12 m. | −12 | 12 | 17 | 3.0 | 75 | 67 | 6.5 | 71.0 |
| 2 p.m. | −10 | 12 | 17 | 0.0 | 75 | 67 | 0.0 | 71.0 |
| 4 p.m. | −12 | 6 | 11 | 6.0 | 82 | 76 | 8.0 | 79.0 |
| 5 p.m. | −11 | 4 | 9 | 2.0 | 83 | 77 | 1.0 | 80.0 |
| 9 a.m. | −16 | −4 | 0 | 8.5 | 88 | 87 | 7.5 | 87.5 |

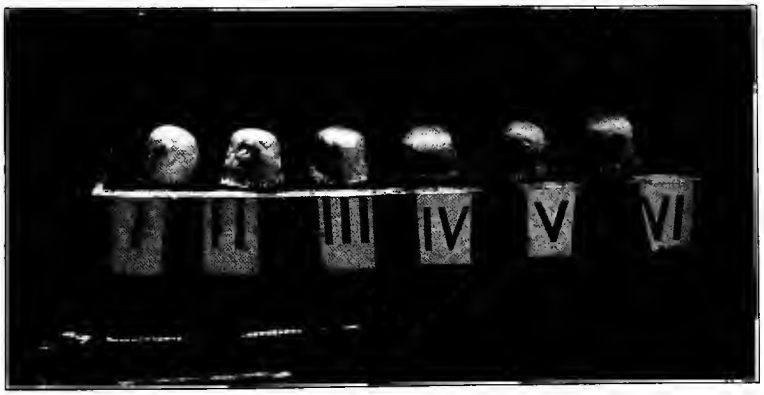
MELTING DOWN TESTS. The melting down tests were run in two groups of six samples each. Each group consisted of 4 gelatin creams and 2 substitute creams. The creams were taken from sealright containers and the weight of the cream determined. The melting down was done on a wire screen of 1/3-inch mesh. Weighings of the drippings were recorded at one-half hour intervals up to 3½ hours, and again at 24 hours. The pictures and data show the almost complete melting down of the gelatin samples, while the substitutes leave an unmeltable residue which is more or less gummy in character.

Picture showing the six ice creams at the start of the melting-down test. Numbers 1, 2, 5, and 6 are ice creams made with Gelatin as a Stabilizer. Number 3 was made with Krabyn and Number 4 with Tragon.


Same after ½ hour.



Same after 1 hour.



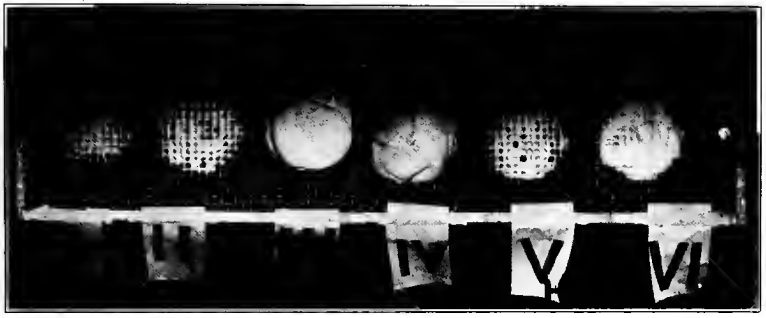

Same after 1½ hours.


Same after 2 hours.

Same after 2½ hours.

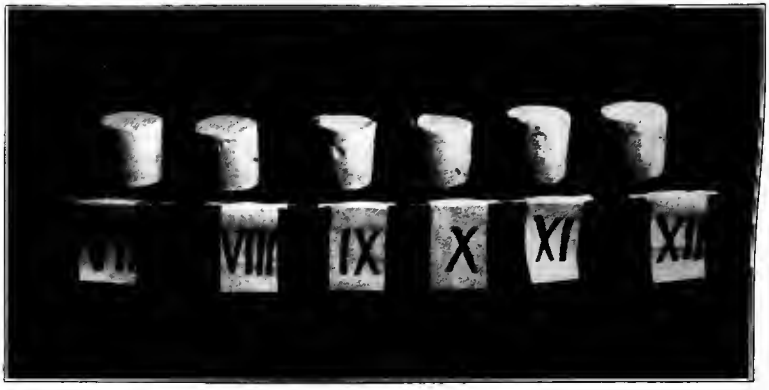
Same after 3 hours.

Same after 3½ hours. Note that the Gelatin creams have melted down completely while the ice creams made with Krabyn and Tragon have left an unmeltable residue.



Top view of screen after 3½ hours.

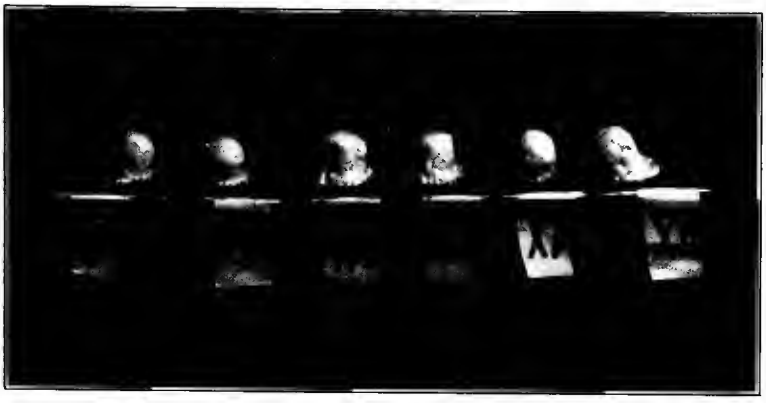
Top view of screen after 24 hours, showing the unmeltable residue left by the ice creams made with Krabyn and Tragon.




Picture showing the second set of six ice cream samples at the start of the melting-down test. Numbers 7, 8, 11, and 12 are ice creams made with Gelatin as a Stabilizer. Number 9 was made with Stabilor and Number 10 with Collace.


Same after ½ hour.


Same after 1 hour.

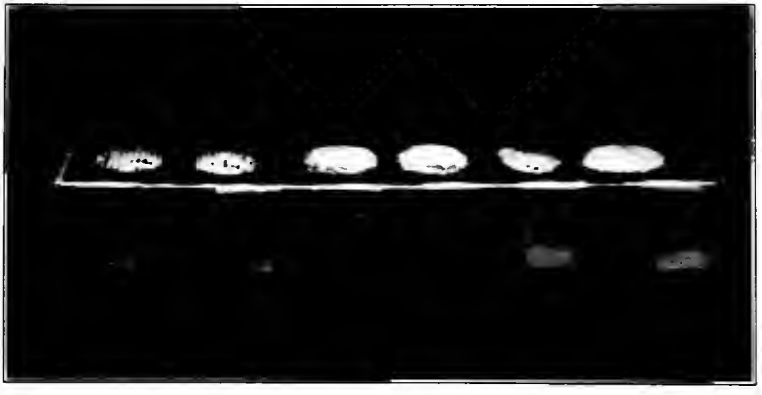


Same after 1½ hours.

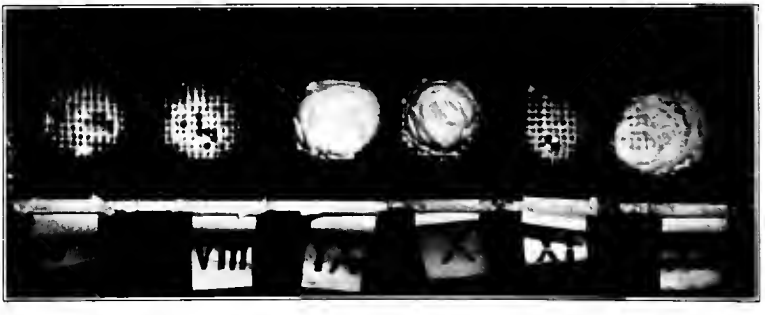
Same after 2 hours.

Same after 2½ hours.

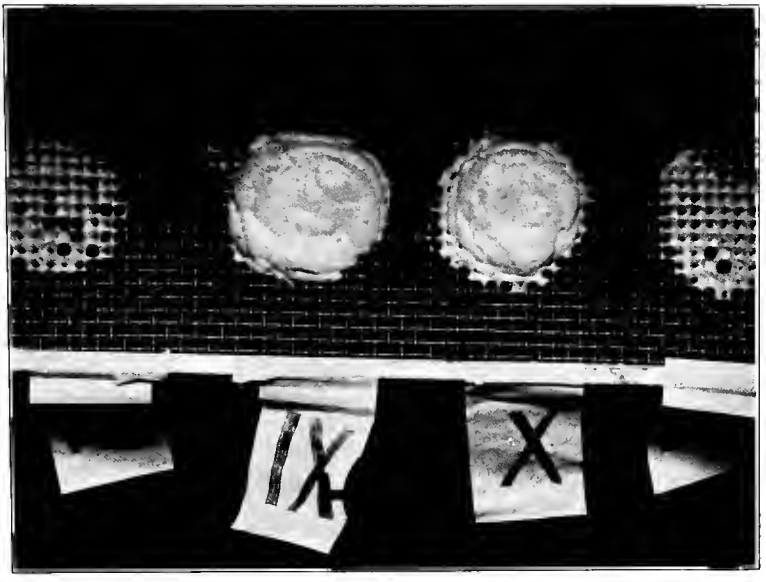
Same after 3 hours.



Same after 3½ hours.



Top view of screen after 3½ hours.




Top view of screen after 24 hours showing the unmeltable residue left by the ice creams made with Stabilor and Collace.

## DATA ON MELTING-DOWN TESTS

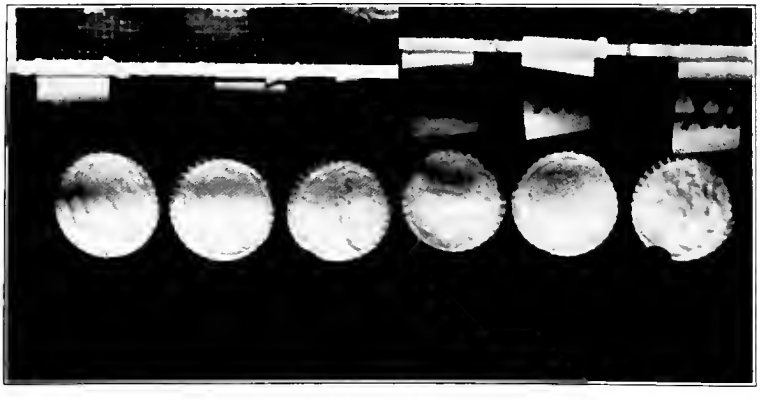
| | | Weight in Grams of the Drippings from the Melting Ice Cream | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Sample No.* | *Weight at Start* | *½ Hr.* | *1 Hr.* | *1½ Hrs.* | *2 Hrs.* | *2½ Hrs.* | *3 Hrs.* | *3½ Hrs.* | *24 Hrs.* | *Loss of Weight* |
| 1 | 253 gms. | 0 | 44 | 81 | 143 | 194 | 221 | 240 | 246 | 7 gms. |
| 2 | 245 | 0 | 22 | 61 | 117 | 170 | 215 | 226 | 233 | 12 |
| 3 | 244 | 0 | 16 | 44 | 83 | 105 | 148 | 180 | 208 | 36 |
| 4 | 239 | 0 | 25 | 34 | 63 | 100 | 121 | 170 | 193 | 46 |
| 5 | 246 | 0 | 22 | 57 | 118 | 172 | 217 | 236 | 236 | 10 |
| 6 | 256 | 0 | 23 | 62 | 104 | 157 | 205 | 239 | 239 | 17 |
| 7 | 241 | 10 | 85 | 147 | 229 | 240 | 240 | | 240 | 1 |
| 8 | 242 | 6 | 73 | 133 | 219 | 241 | 241 | | 241 | 1 |
| 9 | 240 | 3 | 50 | 89 | 141 | 181 | 200 | 203 | 203 | 37 |
| 10 | 231 | 6 | 67 | 110 | 167 | 194 | 203 | 207 | 207 | 24 |
| 11 | 254 | 11 | 85 | 146 | 232 | 253 | 253 | | 253 | 1 |
| 12 | 249 | 9 | 73 | 116 | 190 | 224 | 228 | 229 | 239 | 10 |

Temperature at which Samples 1-6 were melted down was 67° F.
Temperature at which Samples 7–12 were melted down was 77° F.
Samples number 3, 4, 9, and 10 are those made with the substitutes.

Drippings. A difference could also be noted in the appearance of the drippings. In the accompanying photographs one can easily see the more or less rough appearance of the substitute drippings as compared to the smooth drippings of the gelatin.


Picture showing the drippings from the melted ice creams. Note the more or less rough appearance of the drippings from the creams made with Krahyn and Tragon as compared to the smooth appearance of the drippings of the creams made with Gelatin.

Numbers 1, 2, 5, and 6 are ice creams made with Gelatin; Number 3 is made with Krahyn, and Number 4 is made with Tragon.



Picture showing the drippings from the melted ice creams. Note the more or less rough appearance of the drippings from the creams made with Stabilor and Collace as compared to the drippings of the creams made with Gelatin.

Numbers 7, 8, 11, and 12 are ice creams made with Gelatin; Number 9 is made with Stabilor, and Number 10 is made with Collace.

Samples of these drippings were collected in test tubes and placed in a refrigerator overnight. A separation could be noticed in the substitutes that was not seen in the gelatin drippings. On standing, this separation became more noticeable in the case of the drippings from the ice cream made with substitutes while there was no separation in the drippings of the ice cream made with gelatin.

The same separation was also seen in the ice cream mixes before freezing.

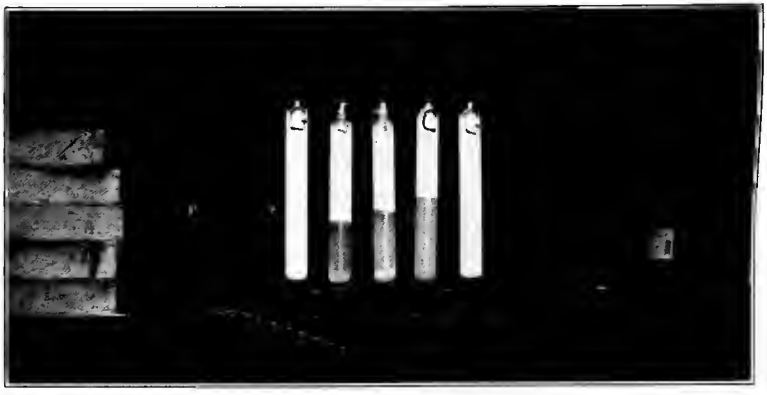
Organo-leptic Tests. Many food products can be subjected to chemical or bacteriological analysis and their quality judged thereby. Such a judgment, however, is incomplete, since it does not present the evidence or take into consideration the function of gustation — the attractiveness to the taste of the consumer. There are no direct means of measuring flavor and odor, and yet these play a very important part in the commercial quality of a food product.

In addition to the laboratory tests, a comparison of food products by the organo-leptic tests is therefore very important in arriving at an opinion as to the degree to which a food product will meet the demands of the public.

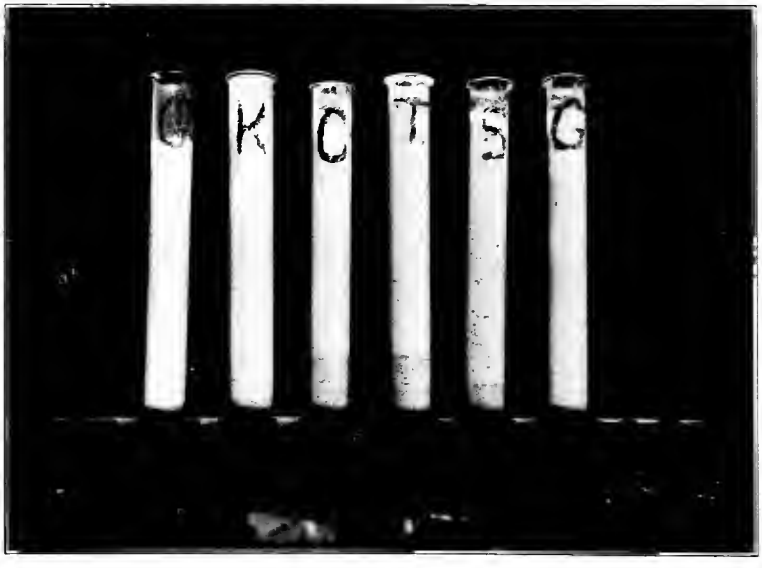
Such an opinion can in a large measure be determined by securing the intelligent judgment of a group of competent individuals of discriminating taste, but who are free from bias because of lack of definite information as to the findings of chemical analysis or bacteriological examination, and are free to express only their own reactions based on the sensory tests of sight, odor and taste.

In order to secure such unbiased group opinion a series of tests was carried out in which twenty-five individuals coöperated. Each was supplied with a small number of samples of ice cream, never more than three, on which he was to pronounce his personal opinion as to quality without any communication or collusion with any other individual. The results of the taste-test examinations made by such a group were then collected and separated into 3 groups, first choice, second choice and third choice. The results of each individual were reported under the headings of "Flavor" and "Texture," these terms being approximately defined as follows:

Flavor — the quality of being pleasing to the taste of the individual.



Picture showing the separation in the ice cream mixes on standing at 40° C. for 48 hours. Note that the separation occurs only in the mixes containing substitutes. From left to right the tubes contain mixes made with the following stabilizers, Gelatin, Stabilor, Tragon, Collace, and Gelatin.



Picture showing separation in the ice cream after melting down and standing at 40° C. for 48 hours. The tubes from left to right contain ice creams made with the following stabilizers: Gelatin, Krabyn, Collace, Tragon, Stabilor, and Gelatin. Note that there is no separation in the creams made with Gelatin and that the separation is only slight in the cream made with Krabyn.

Texture — visual appearance and consistency or "feel" in the mouth.

As a check, similar tests were made by two experts connected with the ice cream manufacture.

The first set of tables shows the result of the individual tests, while the second set shows the summarized results.

The summarized opinions are also shown in Graphs III and IV.

On this basis of comparison it was found that the ice cream made with gelatin is preferred by the individuals representing the intelligent consumers by a vote of 81 to 19, or approximately 4 to 1. The experts in ice cream making and testing also gave their preference to ice cream made with gelatin by a vote of 8 to 0, a distinct preference for ice cream made with gelatin.

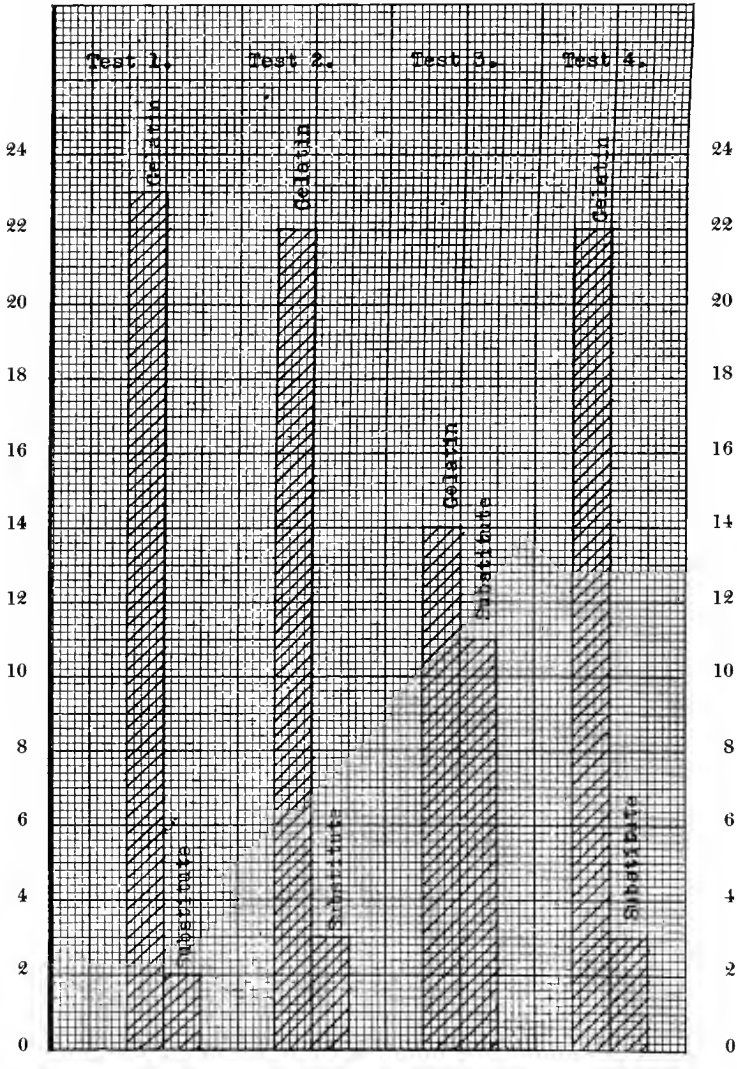
Appearance of Ice Cream. On scooping out the ice cream a lack of cohesiveness on the part of the ice creams made with substitutes could be noticed, while that made with gelatin was smoother, more uniform and more firm.

RESULTS OF FOUR TASTING TESTS AS CONDUCTED WITH TWENTY-FIVE INDIVIDUALS

| | | *1st* | *2d* | *3d* | *Flavor* | | | *Texture* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sample* | *Place* | *Place* | *Place* | *Good* | *Fair* | *Poor* | *Good* | *Fair* | *Poor* |
| | 1 | 6 | 8 | 11 | 10 | 10 | 5 | 7 | 13 | 5 |
| (1) | 2 | 17 | 4 | 4 | 13 | 8 | 4 | 17 | 4 | 4 |
| | Krabyn | 2 | 13 | 10 | 10 | 12 | 3 | 4 | 11 | 10 |
| | 3 | 9 | 9 | 7 | 12 | 11 | 2 | 13 | 11 | 1 |
| (2) | 4 | 13 | 11 | 1 | 19 | 5 | 1 | 19 | 4 | 2 |
| | Tragon | 3 | 5 | 17 | 9 | 10 | 6 | 7 | 9 | 9 |
| | 5 | 10 | 8 | 7 | 16 | 8 | 1 | 15 | 6 | 4 |
| (3) | 7 | 4 | 10 | 11 | 13 | 10 | 2 | 8 | 8 | 9 |
| | Stabilor | 11 | 8 | 6 | 14 | 10 | 1 | 14 | 8 | 3 |
| | 6 | 9 | 12 | 4 | 13 | 11 | 1 | 18 | 6 | 1 |
| (4) | 8 | 13 | 10 | 2 | 16 | 7 | 2 | 14 | 10 | 1 |
| | Collace | 3 | 5 | 17 | 10 | 13 | 2 | 7 | 14 | 4 |

## GRAPH III

GRAPH SHOWING RESULTS OF FOUR TASTING TESTS
ON TWENTY-FIVE INDIVIDUALS



## RESULTS OF TASTING TESTS AS CONDUCTED WITH TWO EXPERTS

| | Sample | 1st Place | 2d Place | 3d Place | Flavor Good | Flavor Fair | Flavor Poor | Texture Good | Texture Fair | Texture Poor |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 2 |
| (1) | 2 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| | Krabyn | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 2 |
| | 3 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 |
| (2) | 4 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 2 |
| | Tragon | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 |
| | 5 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| (3) | 7 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| | Stabilor | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 2 |
| | 6 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 2 |
| (4) | 8 | 2 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 2 |
| | Collace | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 2 |

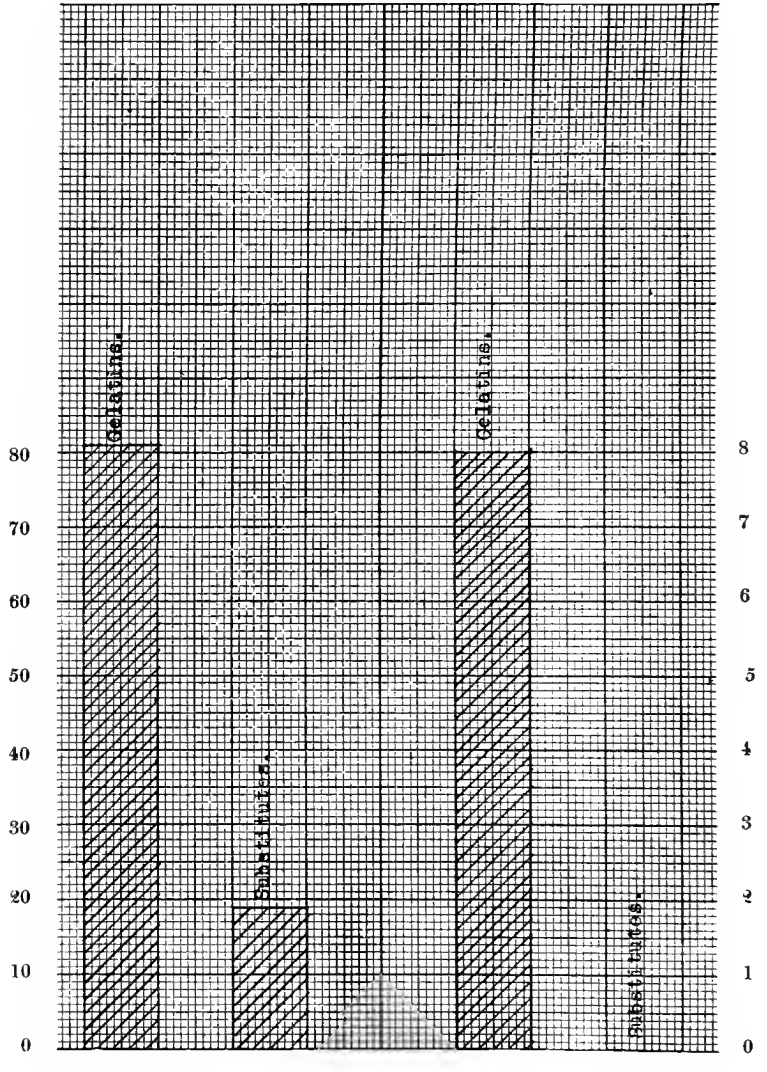
## SUMMARY OF RESULTS OF FOUR TASTING TESTS AS CONDUCTED WITH TWENTY-FIVE INDIVIDUALS

| Sample | 1st Place | 2d Place | 3d Place | Flavor Good | Flavor Fair | Flavor Poor | Texture Good | Texture Fair | Texture Poor |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 8 | 11 | 10 | 10 | 5 | 7 | 13 | 5 |
| 2 | 17 | 4 | 4 | 13 | 8 | 4 | 17 | 4 | 4 |
| 3 | 9 | 9 | 7 | 12 | 11 | 2 | 13 | 11 | 1 |
| 4 | 13 | 11 | 1 | 19 | 5 | 1 | 19 | 4 | 2 |
| 5 | 10 | 8 | 7 | 13 | 11 | 1 | 18 | 6 | 1 |
| 6 | 9 | 12 | 4 | 13 | 11 | 1 | 18 | 6 | 1 |
| 7 | 4 | 10 | 11 | 13 | 10 | 2 | 8 | 8 | 9 |
| 8 | 13 | 10 | 2 | 16 | 7 | 2 | 14 | 10 | 1 |
| Krabyn | 2 | 12 | 10 | 10 | 12 | 3 | 4 | 11 | 10 |
| Tragon | 3 | 5 | 17 | 9 | 10 | 6 | 7 | 9 | 9 |
| Collace | 3 | 5 | 17 | 10 | 13 | 2 | 7 | 14 | 4 |
| Stabilor | 11 | 8 | 6 | 14 | 10 | 1 | 14 | 8 | 3 |

## GRAPH IV

GRAPH SHOWING COMPLETE RESULTS OF TASTING TESTS WITH TWENTY-FIVE INDIVIDUALS

GRAPH SHOWING COMPLETE RESULTS OF TASTING TESTS WITH TWO EXPERTS



SUMMARY OF RESULTS OF FOUR TASTING TESTS AS CONDUCTED WITH TWO EXPERTS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 2 |
| 2 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 3 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 |
| 4 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 2 |
| 5 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 6 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 2 |
| 7 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 8 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| Krabyn | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 2 |
| Tragon | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 |
| Collace | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 2 |
| Stabilor | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 2 |

A certain roughness on the tongue as well as the actual visual appearance of ice crystals was also noticed in the ice cream made with gelatin substitutes, while in the ice creams made with gelatin, ice crystals were absent in most cases and in those few cases where they could be detected, they were hardly noticeable. It is thus obvious that the vegetable products gave larger ice crystals than in the case of gelatin stabilizers.

General Conclusions. While there are no doubt many phases of the use of stabilizers which might be discussed, the outstanding facts as they have appeared in this work may perhaps be summarized in the following statements.

From the standpoint of appearance ice creams containing the gelatins are better looking than those with the substitutes, as the substitutes used all contained dark particles distributed throughout them. These particles are so diffused throughout the mix that they are not especially apparent in the frozen cream; however, a careful examination seems to show a finer appearance in the creams using gelatin.

On the basis of solubility, the gelatins are again to be preferred. The difficulty which is encountered and the time consumed in getting the substitutes into a homogeneous suspension is much greater than with gelatin. The ease of securing a homogeneous mix is a point in favor of the gelatins.

Bacteriologically, a good grade gelatin is much to be preferred to the substitutes examined. The total bacterial counts are usually lower in the case of the gelatins, as are also the counts on molds, protein splitters, gas formers, etc. It is, however, to be emphasized

that only food gelatins of good quality should be employed. Gelatins of poor quality may have disagreeable tastes and odor and high bacterial content. In such cases gelatin is of no greater sanitary advantage than many of the plant substitutes.

The melting down tests show that ice cream made with gelatin will melt down smoothly, while in the case of the substitutes there invariably remained a gummy mass in spite of the use of rather coarse screens.

The data obtained from the sensory test group shows that ice cream made with gelatin is preferred by about 4 to 1 over that made with substitutes, while "experts" prefer it by a vote of 8 to 0. These figures alone show that the ice cream manufacturer who uses gelatin will please more individuals than those using substitutes.

The food value of these various stabilizers is another factor to be considered. It is known that gelatin contains a majority of the essential amino-acids, and also that it has an emulsifying property which prevents the coagulation of casein and hence makes the ice cream more easily mixed with the digestive juices. This factor is important, especially when the ice cream is fed to infants. The substitutes do not have these desirable characteristics. It is recognized that the substitutes contain starch, gums, dextrine or other carbohydrates or carbohydrate-like material which, if digested, has some actual food value. The stabilizer is not used for increasing food value of ice cream, however, so this point has but little significance.

Gelatin also has a colloidal property, that is, it is capable of forming a colloidal suspension. This is also a very important factor as it has to do with the ice crystal formation. The crystals are apparently smaller in the original freezing when gelatin is used. When the temperature of the ice cream rises to a point where there is a softening or slight melting and then cooling again occurs to a point below the freezing point, as frequently happens in the opening and closing of ice cream cabinets, water from the ice crystals tends to remain separate through the action of the protective colloid, and refreezes again in small crystals. In the case of the substitutes, however, when the temperature of the cream goes up and there is a slight melting, there is more separation and the water formed adheres to other crystals so that when it refreezes larger ice crystals are built up. Thus, by accretion crystal size increases so that the crystals can be easily felt in the mouth. These enlarged

crystals are disadvantageous in that they affect the taste as well as the texture of the ice cream.

From the sanitary or public health viewpoint, we can see no objection to the proper use of stabilizers, if clean, high-grade materials are used in proper amounts, since the object in their use is in no way to cheapen or falsify the product, but simply to add to its commercial quality.

As a result of all the phases of the work here carried out the authors are of the opinion that the gelatin stabilizers give a product superior to that obtained by vegetable substitutes.

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